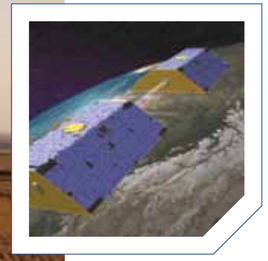


"These [GRACE] maps provide regional to national-level water resource information that was previously unavailable to policy and decision makers. The novel use of satellite-based gravity data in combination with advanced modeling techniques has given us a unique perspective on groundwater that was not resolvable through just ground-based observations."

Brian Wardlow
National Drought Mitigation Center

Enhancing Drought Monitoring in North America

An Applied Sciences project integrated data from the *Gravity Recovery and Climate Experiment* (*GRACE*) satellite mission to improve the U.S. Drought Monitor. Managers and government officials use maps from this premier drought monitoring tool to better manage limited water supplies and distribute drought aid where it is needed most.

An innovative application of Earth observations improved the U.S. Drought Monitor and the classification of drought severity.

Applying Data from Satellites

The National Drought Mitigation Center (NDMC) produces official drought maps and products on a weekly basis. The NASA-funded project, led by NASA hydrologist Matt Rodell, developed new drought indicators using Earth observations from *GRACE*, ground data, and other satellites; these indicators are now part of the NDMC's routine production.

GRACE—a pair of satellites that orbit in tandem about 285 miles above the ground—detects very small variations in the Earth's gravitational field. The variations are used to determine changes in the total amount of water stored both on top of and below the land surface, including snow, surface waters, soil moisture, and groundwater. Having a complete picture of these water types enables better classification of drought severity.

Rodell's team combined *GRACE* data with other observations—including precipitation, temperature, and solar radiation data—and high-resolution numerical modeling to develop a continuous record of soil moisture and groundwater dating back to 1948. The team then used the soil and groundwater record to produce weekly maps of wetness conditions in the soil and aquifers.

This project generated an independent and reliable data set, which augmented the existing data available to assess droughts. Prior to the addition of the new *GRACE*-based drought indicators, the U.S. Drought Monitor lacked information on deep soil moisture and groundwater storage. The officials who produce the Drought Monitor's weekly maps can use this valuable information to gauge the impact of long episodes of wet or dry weather.

The NDMC is located at the University of Nebraska, Lincoln. The U.S. Department of Agriculture (USDA) and the National Oceanic and Atmospheric Administration (NOAA) are the primary federal agencies sponsoring the Drought Monitor.

Facilitating Decisions

The U.S. Drought Monitor authors make routine use of the soil moisture and groundwater data from the project team. "For us, it is another voice in the room to answer questions about soil moisture. It does help greatly to define the long-term and short-term drought situation, as well as provide details for inclusion in the weekly narrative, where the author explains if impacts are hydrologically and/or ecologically devastating, or having more of an impact on agriculture and society," said Matt Rosencrans, a meteorologist at the NOAA Climate Prediction Center.

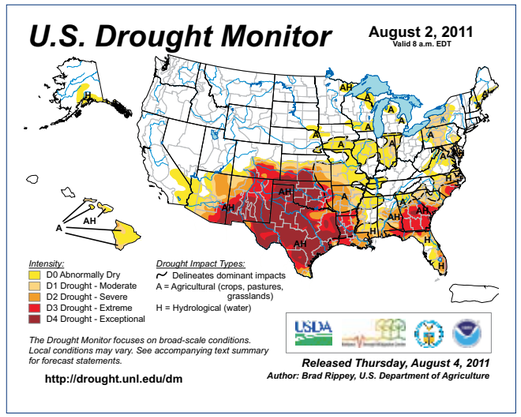
Drought planning entails drought monitoring, understanding drought impacts, and mitigating the associated risks. Enhanced drought monitoring through additional data could improve drought planning on the national, state, local, and tribal level.

Droughts are significant economically. For example, the USDA Livestock Forage Disaster Program disbursed $479 million for drought-related grazing losses of livestock from 2008 through 2011. The program uses U.S. Drought Monitor ratings of severe and extreme drought by county to determine eligibility for compensation. In 2011, the cost of the Texas drought in livestock and crop losses exceeded $7.6 billion plus more in damages from drought-related wildfires.

Expanding Potential Applications

The project's data products not only benefit official drought monitoring. The team posts its weekly groundwater and soil moisture maps online, allowing people to tap the data for their own assessments and decisions. The maps are especially useful in helping water resources managers differentiate between short-term and long-term drought.

The *GRACE*-based data products may ultimately support long-term planning, as decisions on issues such as disaster aid, construction of dams, and water allocation rely on accurate assessments of drought. Rodell's project team included people from the NDMC, NOAA, and the University of California, Irvine. In 2012, the team plans to expand the techniques globally.



U.S. Drought Monitor map, August 2, 2011.

GRACE is a U.S.-German satellite mission. NASA and the German government have agreed on a *GRACE Follow-On* mission (*GRACE-FO*) for 2017 to continue these important measurements and the long-term record. There are discussions for a *GRACE-II* mission to improve the accuracy and resolution of the measurements.

The U.S. Drought Monitor is available on the NDMC website: *http://www.drought.unl.edu*.

To view the weekly groundwater and soil moisture condition maps, visit *http://www.drought.unl.edu/MonitoringTools/NASAGRACEDataAssimilation.aspx*.